CHAPTER 6.
BOISE CREEK STREAM HABITAT

The Boise Creek basin has been significantly degraded by land use activities. Although the habitat of the Boise Creek Basin is impaired (Kerwin 1999), it remains one of the most productive salmon and steelhead tributaries not only in the White River Basin (King County 1993) but in all of King County. Anadromous fish species known to inhabit Boise Creek include chinook salmon (*Oncorhynchus tshawytscha)*, coho salmon (*O. kisutch)*, and steelhead (*O. mykiss)* (Kerwin 1999). The distribution of anadromous species in the watershed is limited by a natural falls at river mile (RM) 4.4, just upstream of the Enumclaw Golf Course. Resident rainbow (*O. mykiss)* and cutthroat trout (*O. clarki)* inhabit the reaches upstream of this barrier. Bull trout (*Salvelinus confluentus)* may also occur in the basin.

The *Salmon Habitat Limiting Factors* report for Water Resources Inventory Area (WRIA) 10 identified numerous habitat impairments in the Boise Creek watershed (Kerwin 1999). These impairments include poor floodplain connectivity, bank instability, lack of large woody debris, limited pool habitat, few side channel habitats, fine substrate deposition in some stream reaches, poor riparian habitat, water quality impairment (high water temperature), and water quantity problems, specifically low base flow conditions. The report also notes that several small bridges constrict the channel. The 21°C water temperatures observed in certain locations within Boise Creek during the late summer/early fall exceed water temperature standards for Class A waters, which require that freshwater temperatures not exceed 18°C (WAC 173-201A). Because of this, Boise Creek has been added to Washington State's 303(d) list of impaired waterbodies. These high temperatures may limit salmonid use of the basin, in particular bull trout, which prefer temperatures below 10°C (Bonneau and Scarnecchia 1996) and are rarely found in streams warmer than 15°C (Dunham et al. in press).

The impairments to Boise Creek habitat are largely a result of channelization and straightening, construction of levees and revetments, and removal of large woody debris (LWD) and riparian vegetation. Straightening and channelization has also decreased the natural sinuosity of the stream in many locations, reduced habitat complexity, and eliminated off-channel habitats. The removal of riparian vegetation has compounded many of these habitat impacts by reducing overhanging cover, shading which moderates extreme temperatures, bank stability, and LWD recruitment (Hicks et al. 1991). These functions have been reduced or eliminated from nearly all of the study area. Large woody debris provides physical structure and cover, creates pools, deflects and breaks up stream flow, and stabilizes stream channels (Murphy and Meehan 1991).

The high temperatures in Boise Creek are likely due to the poor riparian habitat, as increased temperatures are often related to lack of shade (Hicks et al. 1991), especially in headwater areas (Poole et al. 2001). Removal of riparian vegetation has also reduced bank stability, thereby increasing bank erosion and fine sediment loading to the stream. Most of the major stream channels within the Boise Creek basin are homogenous, dominated by riffle and run habitats and lacking pools. O'Rollins (1993) reported that in Boise Creek, pools were more abundant in areas with healthy riparian vegetation and LWD, and that 63 percent of the pools observed in these more pristine areas were formed by LWD. These results suggest that the lack of in-stream LWD in Boise Creek is a causative factor for the poor habitat diversity in the stream

6.1 STREAM HABITAT CLASSIFICATION METHODS

The stream habitat analysis for this report was conducted on Subbasins 1 through 5 using a modification of the Tri-County Urban Issues Study: Urban Stream Baseline Evaluation Methods (USBEM) Phase 1 method (R2 Resource Consultants et al. 2001). Subbasins 6 and 7 were not included in the detailed analysis, but a general description is provided.

The USBEM Phase I method incorporates features of several methodologies commonly used in the Pacific Northwest to characterize fish habitat using physical, biological, and chemical indicators. Since the USBEM methodology was designed for an urban setting, and the Boise Creek basin is a rural watershed, the methodology was adapted to better fit this setting. The USBEM Phase I method served as a foundation, then additional criteria were added during the scoping process for the project. The selected criteria were relevant for indicating the health of the basin and stream habitat conditions. The criteria used in this investigation are described below.

6.1.1 General Characteristics

The general characteristics section of the evaluation provides a summary of descriptive information about each subbasin, identification of stream channel types, and the total length of each channel type in the subbasin. Lengths of each stream channel type were determined from existing maps and aerial photographs.

The channel type was determined for each stream reach, according to the USBEM Phase I methods. The seven channel process groups described by Paustian et al. (1992) were identified by R2 Resource Consultants and others as representative of freshwater channel types found in northwestern Washington. The channel type descriptions presented below are from R2 Resource Consultants et al. (2001):

- **Palustrine**—Wetland channels, beaver complexes or sloughs. Velocities are generally low, substrates are composed of fine sediment or organic matter, and channel morphology is sinuous or irregular and dominated by pools or glides. Stream gradient is very low (<1 percent).
- **Floodplain**—Low-gradient (<2 percent) depositional channel. Substrates generally consist of small gravel to cobble, and the bedform is typically regularly spaced pools and riffles. Large woody debris plays an important role in these channels for forming pools and providing cover. These channels also migrate freely across floodplains, and off-channel habitats are normally abundant.
- **Alluvial Fan**—Moderate-gradient (2 to 8 percent) depositional channels located in the transitional area between steep slopes and valley floodplains. Stream power decreases longitudinally down the fan, and deposition results in channels that migrate freely across the fan. Substrates typically range

from gravel to cobble, pools are often relatively small and shallow, and off-channel habitats typically do not persist over the long-term.

- **Large Contained**—Low- to moderate-gradient (1 to 3 percent) channels that are moderately to deeply incised. Stream power is moderate to high with coarse substrates. LWD is easily transported and generally located along channel margins. These channels rarely have extensive off-channel habitats.
- **Moderate Gradient Mixed Control**—Transport-dominated channels with moderate to high stream power. Gradients range from 2 to 8 percent. LWD is important for forming pools and storing sediment; thus substrates and bedforms are highly variable. Off-channel habitats may be present, but are not abundant.
- **Moderate Gradient Contained**—Transport-dominated channels with moderate to high stream power. Gradients are typically from 2 to 4 percent, but may reach 6 percent. LWD is important for forming pools and storing sediment; thus substrates and bedforms are highly variable. Off-channel habitats are rare.
- **High Gradient Contained**—Moderately to deeply incised channels with high stream power and gradients greater than 4 percent. Most sediment is easily transported; thus gravel and small cobbles deposit only in hydraulically protected areas. Pools tend to be small and shallow, although LWD and bedrock may form large deep pools.

6.1.2 Subbasin Alteration

An analysis was performed to identify significant alterations to the watershed and/or stream channels within the Boise Creek basin using the criteria listed below and in Table 6-1 as indicators of biological, physical, or chemical parameters that can affect habitat quality. These criteria and a matrix of indices were also used to assess the degree of overall watershed modification of the basin from forested conditions.

Effective Impervious Area

Effective impervious area (EIA) represents the percentage of impervious surface in a given area. This metric can indicate the relative change to a catchment by development. Values are presented in the land cover analysis portion of this report (Chapter 2), based on existing land use information supplied by King County.

A study by Booth and Jackson (1997) explored the relationship between increased EIA and flow magnitudes in five watersheds in King County. They found that an EIA of 10 percent can cause significant degradation to aquatic ecosystems, and even lower levels of EIA are also associated with significant watershed degradation. These authors also noted that areas that were observed to be functioning at a high level typically had EIA values of less than 3.6 percent. The following thresholds were used to classify the level of alteration to the subbasin indicated by the EIA:

- >10 percent EIA indicates a high level of alteration.

- 5 to 10 percent EIA indicates a moderate level of alteration.
- <5 percent EIA indicates a low level of alteration.

Landscape Alteration

Change to the landscape by anthropogenic activities was examined using the land cover analysis data from Chapter 2. The change to the landscape was assessed by calculating the percent of the remaining forested land cover compared to historical conditions for each subbasin. It was assumed that each subbasin was 100 percent forested prior to development. The thresholds for the low, moderate, and high levels of alteration for this criterion are presented in Table 6-1.

Impact from Culverts and Other Stream Crossings

Impacts from culverts and other stream crossings were determined for each reach. This criterion was evaluated by determining the number of stream crossings per mile and the percentage of the total stream channel length located within storm drainpipes or culverts. Known passage barriers at stream crossings were also reported.

Flow Modification

This criterion evaluated changes in stream hydrology, which can indicate the extent of alterations to a watershed. Hydrologic data presented in Chapter 3 were examined for significant changes to the hydrologic regime from pre-development to existing conditions. The analysis was based on results of a study by Bledsoe and Watson (2001) on the effects of urbanization on stream channel stability. They used the ratio of the 2-year flow after development to the 2-year flow prior to development ($Q2_{post}/Q2_{pre}$) to compare changes in flows to effects on channel stability. The study also indicated that EIAs from 10 to 20 percent could cause a two-fold increase in the frequency of pre-development 2-year flow events, and result in severe stream channel destabilization. Furthermore, the effects of increased EIA were more pronounced in smaller watersheds.

Bledsoe and Watson's results were consistent with those obtained by Booth and Jackson (1997), suggesting that an EIA as low as 10 percent can have a dramatic impact on stream habitat. The $Q2_{post}/Q2_{pre}$ ratio was used to evaluate the level of hydrologic change to the Boise Creek subbasins. The $Q2_{post}/Q2_{pre}$ ratio was calculated for each hydraulic modeling reach (RCHRES). The following thresholds were used to classify the level of alteration:

- High level of modification: $Q2_{post}/Q2_{pre}$ ratio > 1.75
- Moderate level of modification: $Q2_{post}/Q2_{pre}$ ratio 1.25-1.75
- Low level of flow modification: $Q2_{post}/Q2_{pre}$ ratio <1.25

Channel Modifications and Floodplain Connectivity

This criterion was used to indicate the relative level of alteration to the stream channel and floodplain within each stream segment. The level of alteration was determined by estimating the percentage of total stream length enclosed in storm drainage pipes and culverts, as well as the percentage that has been armored, channelized, levied, or otherwise constricted. This information was collected from aerial photographs and other existing information. Thresholds for this criterion are presented in Table 6-1.

Riparian Alteration

Riparian areas are the one of the most complex ecological systems and are an essential component to healthy stream habitat conditions (Naiman et al. 2000). Riparian areas provide thermal insulation for the stream, prevent excessive streambank erosion, trap sediment from runoff, provide overhanging cover for fish, and are a significant source of LWD to the stream (Wenger 1999). Riparian vegetation also contributes to the food web of the stream by depositing leaves and other organic debris as well as providing habitat for terrestrial insects, which are a significant food source for fish (Rondorf et al. 1990). Throughout the Pacific Northwest, riparian forests historically formed a continuous corridor of vegetation along a stream channel (Naiman et al. 1992), but human impacts have altered these conditions (Naiman et al. 2000).

Two methods were used to analyze riparian habitat. The first method calculated the percentage of the total riparian area within each land cover type using data from the land cover analysis section of this report. These data allow comparisons to be made of riparian habitat conditions in various land cover types within a 200-foot wide riparian corridor. It was assumed that prior to development the riparian corridor was 100 percent forested. The ratio of the existing forested land cover to predevelopment conditions was used to indicate the magnitude of alteration. Thresholds for this analysis are presented in Table 6-1.

In the second method, the frequency of riparian breaks was used as an indicator of the longitudinal integrity of the riparian corridor. Riparian breaks included road-crossings, pipelines, and other areas where riparian vegetation is absent. For this analysis, the number of riparian breaks per mile of stream was calculated. Thresholds for this analysis are shown in Table 6-1.

Subbasin Alteration Matrix

The subbasin alteration matrix (Table 6-1) was used to indicate the overall level of alteration and classification of existing habitat conditions, and to identify the most significant factors associated with habitat degradation in each subbasin. The criteria contained in this matrix are a useful guide for identifying and prioritizing habitat improvement projects.

6.1.3 Benthic Index of Biotic Integrity

Indices of biotic integrity use biological data to numerically depict a stream's relative ecological health. The benthic index of biotic integrity (B-IBI) used by King County accomplishes this by comparing the existing abundance of invertebrate taxa to what would be expected under pristine conditions. Taxa of particular interest are the aquatic insect families Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddis flies). These three taxa are associated with healthy or pristine systems, and their reduced levels can indicate impacts such as sedimentation, water pollution, or increased water temperatures. The B-IBI methodology used by the King County Road Services Division was developed specifically for Western Washington. It should be noted that B-IBI data were not available for all of the Boise Creek subbasins. Also, the data may be biased because the samples were collected only at road crossings.

TABLE 6-1.
SUBBASIN ALTERATION MATRIX.

Criteria	Level of Alteration: High: Two or more of the following	Moderate: One or more of the following	Low: All of the following
Effective Impervious Area	>10%	5-10%	<5%
Landscape Alteration	<60% of subbasin forested	60-75% of subbasin forested	>75% of subbasin forested
Impact from Culverts and Other Stream Crossings	>5 per mile	2-5 per mile	<2 per mile
Flow Modification (Q2post/Q2pre ratio)	$Q2_{post}/Q2_{pre} > 1.75$	$Q2_{post}/Q2_{pre} = 1.25 - 1.75$	$Q2_{post}/Q2_{pre} < 1.25$
Channel Modifications and Floodplain Connectivity	>25 % of the stream length is modified	10-25% of stream length is modified	<10% of stream length is modified
Riparian Alteration	<60% of corridor forested or >5 riparian breaks/mile	60-80% of corridor forested or 2-5 breaks/mile	>80% of corridor forested and <2 breaks/mile

The King County Roads Division used a 5-metric scoring method in 1999 and a 10-metric method in 2000 and 2001. Although the number of metrics used was different, the interpretation of the scores is the same (see Table 6-2). The individual metric scores are also indicators of stream health; a value of “5” represent a range of results indicative of an undisturbed site, “3” indicates a somewhat degraded site, and “1” indicates a severely degraded site (Table 6-3).

TABLE 6-2.
INTERPRETATION OF B-IBI TOTAL SCORES.

10-Metric Score	5-Metric Score	Stream Condition
46-50	23-25	Excellent
38-44	19-22	Good
28-36	14-18	Fair
18-26	9-13	Poor
10-16	5-8	Very Poor

6.1.4 Subbasin Summary

Field Investigation and Verification

A field investigation was conducted to verify the results of the above analyses using a modification of Phase II of the USBEM methodology (R2 Resources 2001). It should be noted that the field investigation findings may be somewhat biased. Data were collected only at road crossings, and thus may not fully represent conditions in areas of the watershed with less disturbed stream and riparian habitat conditions.

TABLE 6-3.
THE I-IBI SCORING METHOD (FROM KING COUNTY 2002).

	Score[a]		
Metric	1	3	5
Taxa richness and composition			
Total number of taxa[b]	0-14	15-28	≥29
Number of Ephemeroptera species	0-4	5-8	≥9
Number of Plecoptera species	0-3	4-7	≥8
Number of Trichoptera species	0-4	5-9	≥10
Number of long-lived taxa	0-2	3-4	≥5
Tolerance			
Number of intolerant taxa[b]	0-2	3	≥4
% of individuals in tolerant taxa[b]	≥50	20-49	0-19
Feeding ecology			
% of predator individuals	0-9	10-19	≥20
Number of clinger taxa	0-8	9-18	≥19
Population attributes			
% Dominance (3 taxa)[b]	≥80	60-79	0-59

a. Metrics are scored as 1 (severely degraded), 3 (somewhat degraded), or 5 (undisturbed) depending on the range of values indicated for each metric.
b. Chironomids were not included in these metrics.

Other criteria used to classify habitat included fish passage; riparian condition; embeddedness, substrate composition in spawning areas; streambank condition, pool frequency, channel pattern/bedform, and large woody debris abundance. At each evaluation site, these criteria were classified as good, fair, or poor according to Table 5-7 of the USBEM methodology (R2 Resources 2001), which provides ranges of values for each criterion according to the channel types. The “good” condition rating represents values that are within the range known to support salmonid production; a “fair” rating indicates that salmonid production could be diminished; and the “poor” rating represents unsuitable conditions for sustaining salmonid populations or life stages due to degraded conditions. The thresholds for these criteria are provided in Table 6-4. Evaluation of these criteria was based on professional judgment. These data were collected to provide representative information for each subbasin based on observations made at major access points and under the assumption that conditions at these locations were representative of the subbasin.

TABLE 6-4.
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition: Good	Habitat Condition: Fair	Habitat Condition: Poor
All Streams			
Passage barriers	Upstream and downstream movement by species of concern is not restricted by barriers	Upstream and downstream movement by species of concern is restricted by barriers at some flows	Upstream and downstream movement by species of concern is restricted by barriers at most flows.
Water Temperature	50-57°F For bull trout: 39-48°F (spawning); 36-41°F (incubation); 39-54°F (rearing); <59°F (adult migration)	57-60°F (spawning) 57-64°F (migration and rearing) For bull trout: <39 or 50°F (spawning); <36 or 43°F (incubation); <39 or 55-59°F (rearing); sometimes >59°F (adult migration)	>60°F (spawning) >64°F (migration and rearing) For bull trout: <39 or >50°F (spawning); <34 or >43°F (incubation); >59°F (rearing); regularly >59°F (adult migration)
Palustrine Channels			
Riparian condition	Riparian vegetation is continuous and dominated by native species typical of the channel type.	Riparian vegetation is discontinuous or <50% are native species typical of the channel type	Riparian area is dominated by land use alterations or invasive non-native vegetation
Substrate composition in spawning areas	N/A	N/A	N/A
Embeddedness	N/A	N/A	N/A
Bank condition	N/A	N/A	N/A
Pool frequency	N/A	N/A	N/A
Channel pattern/ bedform	Sinuous pattern with intact connections to adjacent wetlands or side-channels	Sinuous pattern with few connections to adjacent wetlands or side-channels	Straightened pattern; channel is disconnected from adjacent wetlands or side-channels
Large woody debris	N/A	N/A	N/A

TABLE 6-4 (continued).
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition: Good	Fair	Poor
Floodplains			
Riparian condition	High LWD recruitment potential	Medium LWD recruitment potential	Low LWD recruitment potential
Substrate composition in spawning areas	Gravel or cobble is dominant	Gravel or cobble is subdominant	Sand or silt is dominant
Embeddedness	<20% in riffle and pool tailout units	20-40% in riffle and pool tailout units	>40% in riffle and pool tailout units
Bank condition	Perennial vegetation exists along 80% of banks; <20% of banks are exposed soil or artificially hardened	Perennial vegetation exists along 50% of banks; 20-50% of banks are exposed soil or artificially hardened	>50% of banks are exposed soil or artificially hardened
Pool frequency	If CW>60 feet, <5 CW/ pool; if CW<60 feet, <2 CW/pool	If CW>60 feet, 5-7 CW/ pool; if CW<60 feet, 2-4 CW/pool	If CW>60 feet, >7 CW/pool; if CW<60 feet, >4 CW/pool
Channel pattern and connectivity	Sinuous pattern with intact connections to adjacent wetlands or side-channels	Sinuous pattern with few connections to adjacent wetlands or side-channels	Straightened pattern; channel is disconnected from adjacent wetlands or side-channels
Large woody debris	If channel width (CW) is >66 ft, accumulations with at least one key piece are frequent at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, >0.50 key pieces/CW; If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW is >66 ft, accumulations with at least one key piece are scarce at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, 0.20 to 0.50 key pieces/CW; If CW<33 feet, 0.15 to 0.30 key pieces/CW and 1-2 total pieces/CW	If CW is >66 ft, accumulations with at least one key piece are not present at the outside of meander bends, side channel inlets, and bar apexes. If CW is 33 to 66 feet, <0.20 key pieces/CW; If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW